Table 4-77. Detection rates for Pu-239/240 in the sampled media.

Media	Detection Rate	Concentration Range	Number of Detections Higher than the Risk-Based Concentration[a]	Wells Higher than the Risk-Based Concentration
Vadose zone 0 to 35 ft:				
Cores	8.1	0.026 to 1.13 pCi/g	0	None
Soil moisture	0.9	0.70 pCi/L	0	None
Vadose zone 35 to 140 ft:				
Cores	14.3	0.009 to 0.74 pCi/g	0	None
Soil moisture	7.7	0.34 to 3.3 pCi/L	0	None
Vadose zone 140 to 250 ft:				
Cores	2.5	0.013 to 0.14 pCi/g	0	None
Soil moisture	3.1	2.7 pCi/L	0	None
Vadose zone >250 ft:				
Cores	9.0	0.022 pCi/g	0	None
Aquifer-Idaho national Engineering and Environmental Laboratory	1.1	0.094 to 4.3 pCi/L	1	M4D
Aquifer-US. Geological Survey	1.2	0.030 to 0.29 pCi/L	0	None

a. The concentrations for cores are compared to the risk-based concentration (RBC) of **28.7** pCi/g. The soil moisture and aquifer results are compared to a 1E-05 aquifer RBC of 3.5 pCi/L. The RBCs do not apply to soil moisture data but are used here as a basis of comparison.

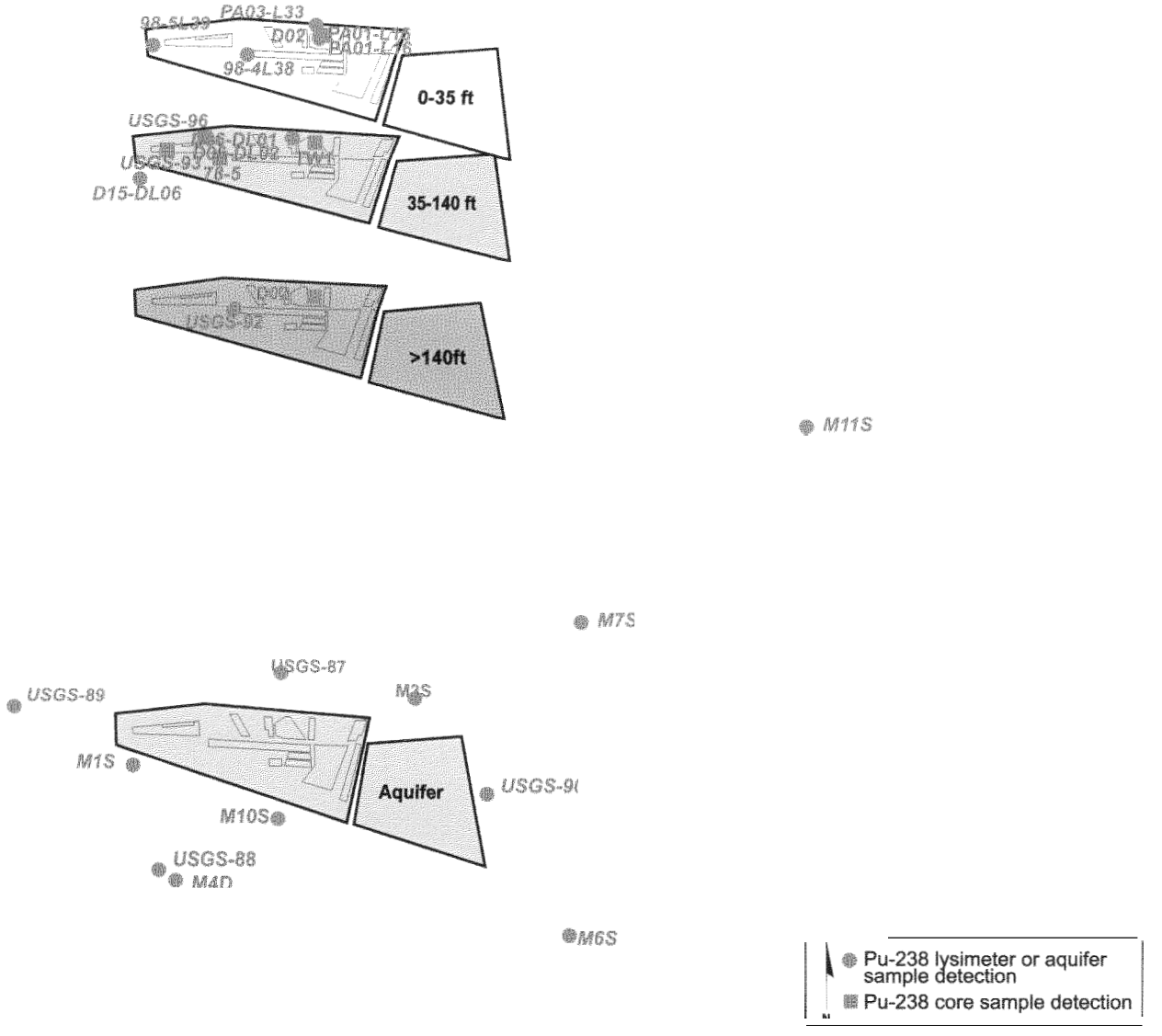

Figure 4-36. Distribution of Plutonium-238 detections in the various sampled media.

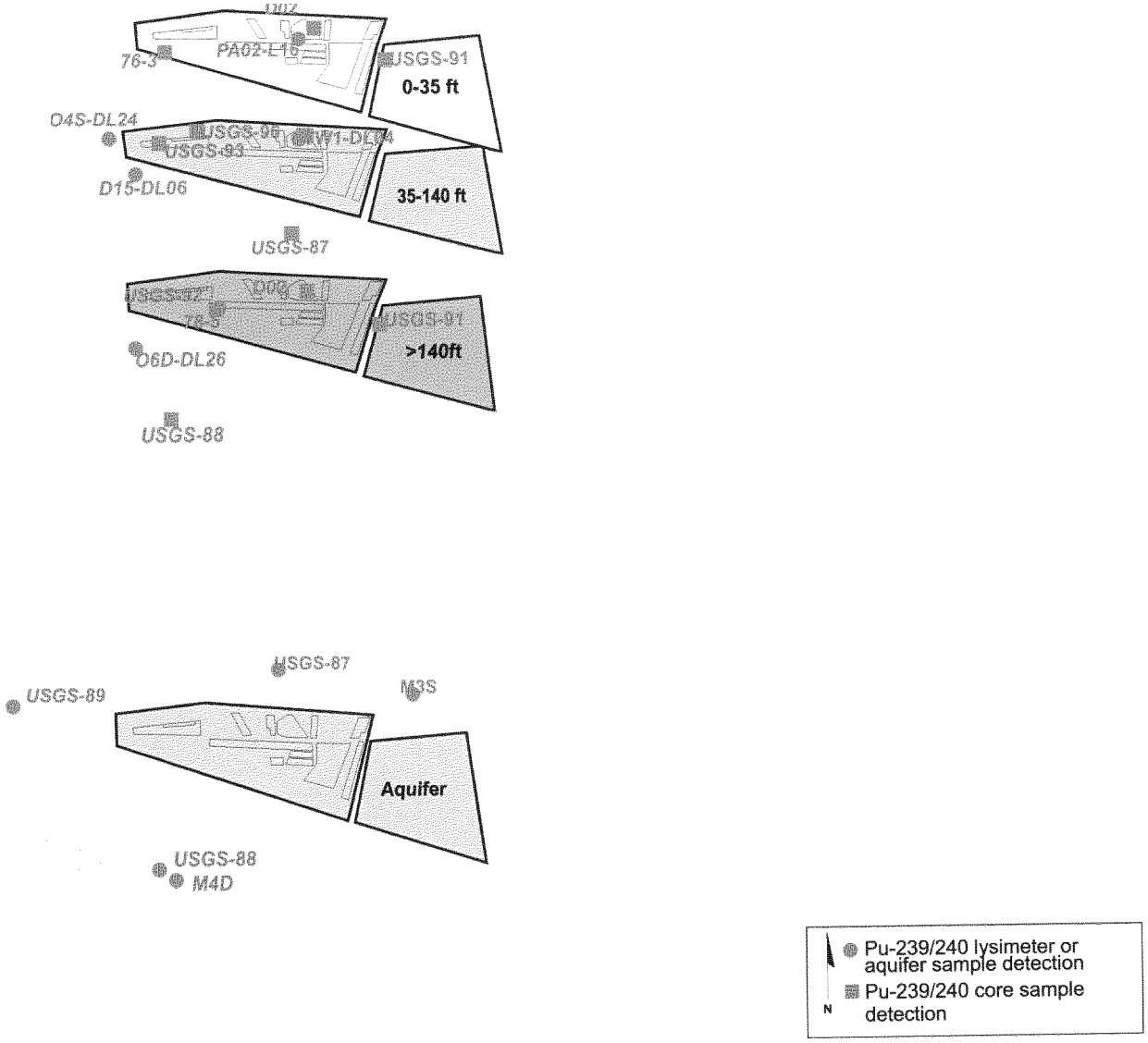

Figure 4-37. Distribution of Pu-239/240 detections in the various sampled media.

4.6.16 Radium-226

Radium-226 is a radioactive decay product in the naturally occurring U-238 decay chain and in the Pu-238 decay chain. The Ra-226 concentrations produced from Pu-238 would be extremely low because of the long half-lives of the intermediary progeny (U-234 and Th-230). Ra-226 decays by the emission of alpha particles and gamma rays, has a half-life of 1.6E+03 years, and was identified in the IRA as a COPC, primarily from the external exposure pathway (Becker et al. 1998). Available information about the presence of Ra-226-bearing waste in the SDA and available Ra-226 monitoring data for all media were reviewed for this report and are summarized below. The sampling data in this section are evaluated against the comparison concentrations in Table 4-78.

Table 4-78. Comparison concentrations for radium-226.

Surface Soil Background Concentration (pCi/g)	Risk-Based Soil Concentration[a] (pCi/g)	Aquifer Background Concentration	Maximum Contaminant Level (pCi/L)	Risk-Based Aquifer Concentration[a] (pCi/L)
2.2[b] 1.2[c]	10.87	Not established	5	1.23

a. The calculated risk-based concentration is equivalent to an increased cancer risk of 1E-05.

b. The background value for gamma spectrometric analysis is unadjusted for U-235 interference (Giles 1998).

c. The background value for gamma spectrometric analysis is adjusted for U-235 interference (Giles 1998).

4.6.76.7 Waste Zone. About 60 Ci of Ra-226 was disposed of in the SDA. Table 4-79 identifies the waste streams containing the Ra-226 activity.

Additional quantities of Ra-226 are being generated over time through ingrowth (see Section 4.1.2). Table 4-79 identifies the amount of Ra-226 that would be produced if the entire parent decayed. Because **of** the long half-lives of the parent nuclides, it will be many thousands of years before substantial ingrowth occurs. However, for completeness, the amount of Ra-226 generated from parent nuclides is listed in Table 4-79. Percentages of the total Ra-226 from parent isotopes are not given because the amount of Ra-226 present is dependant on the timeframe assessed. Radium-226 decays into Pb-210 (see Section 4.6.12).

Spectral gamma logging data provided no information about Ra-226.

Table 4-79. Waste streams containing radium-226.

Waste Stream Code or Waste Generator	Waste Stream Description	Inventory (Ci)	Proportion of Total Activity
OFF-USN-1H	Animal carcasses, waste paper towels, glassware, tools, and laboratory items	4.33E+01	72.3
OFF-ISC-1H	Magnesium-thorium scrap, sources and miscellaneous laboratory equipment	5.00E+00	8.3
OFF-AEF-1H	Wipes, gloves, glassware, and dry activated waste embedded in concrete	3.33E+00	5.6
OFF-DPG-1H	Biological waste	1.67E+00	2.8
TRA-603-8H	Two Ra-226 sources	1.25E+00	2.1
TRA-603-22H	Combustibles	1.25E+00	2.1

Table 4-79. (continued).

Waste Stream Code or Waste Generator	Waste Stream Description	Inventory (Ci)	Proportion of Total Activity (%)
ALE-317-2R	Combustibles	1.10E+00	1.8
TAN-640-1H	Radium-beryllium neutron source	1.00E+00	1.7
ALE-ALE-1H	Building rubble, electric wires, piping, machinery, tracers and sources, glass, gloves, paper, filters, and vermiculite	9.93E-01	1.7
Miscellaneous	Miscellaneous minor streams	1.02E+00	1.7
Total Disposals		5.99E+01	100
Pu-238 ingrowth	Half-life equals 8.78E+01 years. See Section 4.6.13	9.39E+02	NA
U-238 ingrowth	Half-life equals 4.47E+09 years. See Section 4.6.19	3.27E+08	NA
U-234 ingrowth	Half-life equals 2.45E+05 years. See Section 4.6.19	1.03E+04	NA
Th-230 ingrowth	Half-life equals 7.70E+04 years.	1.51E+00	NA

4.6.16.2 Surface. Because Ra-226 has not been a target analyte for surface monitoring, no surface data are available.

4.6.16.3 Vadose Zone. The distributions of Ra-226 in vadose zone core, soil moisture, and perched water in the various depth intervals are discussed below.

Vadose zone core data were compared against one of two surface soil background concentrations, depending on the analytical method used to obtain the result (see Table 4-78). The vadose zone core samples analyzed between 1971 and 1993 were equilibrated and the Ra-226 daughters were measured by gamma spectrometry. Therefore, the 1971 to 1993 Ra-226 data were compared to a background of 1.2 pCi/g. The results from the 1999 and 2000 analyses were obtained by direct measurement of Ra-226 by gamma spectroscopy, unadjusted for U-235 interference, and the 2.1 pCi/g background value was used for comparison.

Radium-226 from the lysimeter samples was analyzed by gamma spectrometric analysis, and the detection limits vary from about 25 pCi/L for an 80-mL sample to 1,000 pCi/L for a 25-mL sample. When larger sample volumes are available, a lower detection limit is achievable, but low concentrations equivalent to the MCL of 5 pCi/L cannot be detected.

4.6.16.3.1 Vadose Zone Core ***Samples***—A total of 109 vadose zone core samples were analyzed for Ra-226 between 1971 and 2000. Seventeen samples yielded Ra-226 concentrations greater than the background concentration for surface soil. All of the samples with relatively high Ra-226 were interbed sediments. Samples with positive detections are shown in Table 4-80.

The vadose zone core analyses between 1971 and 1993 included basalt and interbed samples from 26 cores. Of 32 samples from 26 cores, three results exceeded the applicable background concentrations of 2.2 pCi/g. These three samples were from adjacent Wells 76-4 and 76-4A.

Table 4-80. Positive detections of radium-226 greater than the surface soil background concentration in vadose zone core samples.

Borehole Identification	Sample Depth (ft)	Concentration ± 1 o (pCi/g)	Date
76-4	98.6 to 101.1	3.05 ± 0.17	1976
78-4A	97.8 to 100.2	2.10 ± 0.02	1993
	223.3 to 224.7	2.60 ± 0.02	1993
I-1S	101.6 to 102.0	7.3 ± 1.8	1999 and 2000
	110.6 to 111.0	7.7 ± 1.8	1999 and 2000
I-1D	224.5 to 225.0	7.9 ± 1.6	1999 and 2000
	237.6 to 238.0	6 + 2	1999 and 2000
1-2s	99.0 to 100.0	5.8 ± 1.5	1999 and 2000
	111.0	8 + 2	1999 and 2000
I-2D	223.5 to 224.0	4.3 ± 0.8	1999 and 2000
I-3D	228.5 to 229.0	6.5 ± 1.4	1999 and 2000
I-4S	98.2 to 98.8	3.8 ± 1.2	1999 and 2000
I-4D	229.6 to 230.0	6.4 ± 1.4	1999 and 2000
	237.0 to 237.5	6.1 ± 1.4	1999 and 2000
	237.5 to 238.0	5.2 ± 1.4	1999 and 2000
I-5S	103.5 to 104.0	4.9 ± 1.3	1999 and 2000

The 1999 and 2000 vadose zone core analyses included 32 interbed samples collected from wells inside and outside of the SDA. The 13 samples collected outside the SDA all contained background concentrations. Sixteen of the 19 samples collected from cores inside the SDA exceeded background values. A summary is provided in Table 4-81 of Ra-226 detections in excess of background concentrations in vadose zone cores by depth interval.

Table 4-81. Radium-226 detections in excess of background concentrations in vadose zone cores by depth interval.

Depth Interval (ft)	Detection Greater Than Background/Number of Samples (%)	Range (pCi/g)	Wells or Boreholes with Detections
0 to 35	1/13 (7.7)	1.7	USGS-93
35 to 140	8/55 (14.6)	2.10 to 8	76-4, 76-4A, I-1S, I-2S, I-4S, I-5S
140 to 250	8/38 (21.1)	2.60 to 7.9	76-4A, I-ID, I2D, I3D, 14D
More than 250	0/3 (0)	Not applicable	Not applicable

4.6.16.3.2 Lysimeter Samples at Depths of 0 to 35 ft—

A total of 100 shallow lysimeter samples were analyzed for Ra-226 between 1997 and May 2001 with two (2%) positive detections (see Table 4-82). The detections exceed the MCL for the aquifer, and their occurrence relative to the other shallow lysimeter sampling events is shown in Figure 4-38.

Table 4-82. Positive detections of radium-226 in shallow lysimeters.

Lysimeter	Depth (ft)	Concentration ± 1a (pCi/L)	Confirmation Flag[a]	Date
PA01-L15	14.3	**34 ± 10**	B	September 2000
98-5L39 (SDA10)	10.5	**46 ± 11**	B	May 2001

a. Confirmation flag:
B =Reanalysis performed, no confirmation.
Note: Concentrations in red bold exceed the maximum contaminant level of 5 pCi/L.

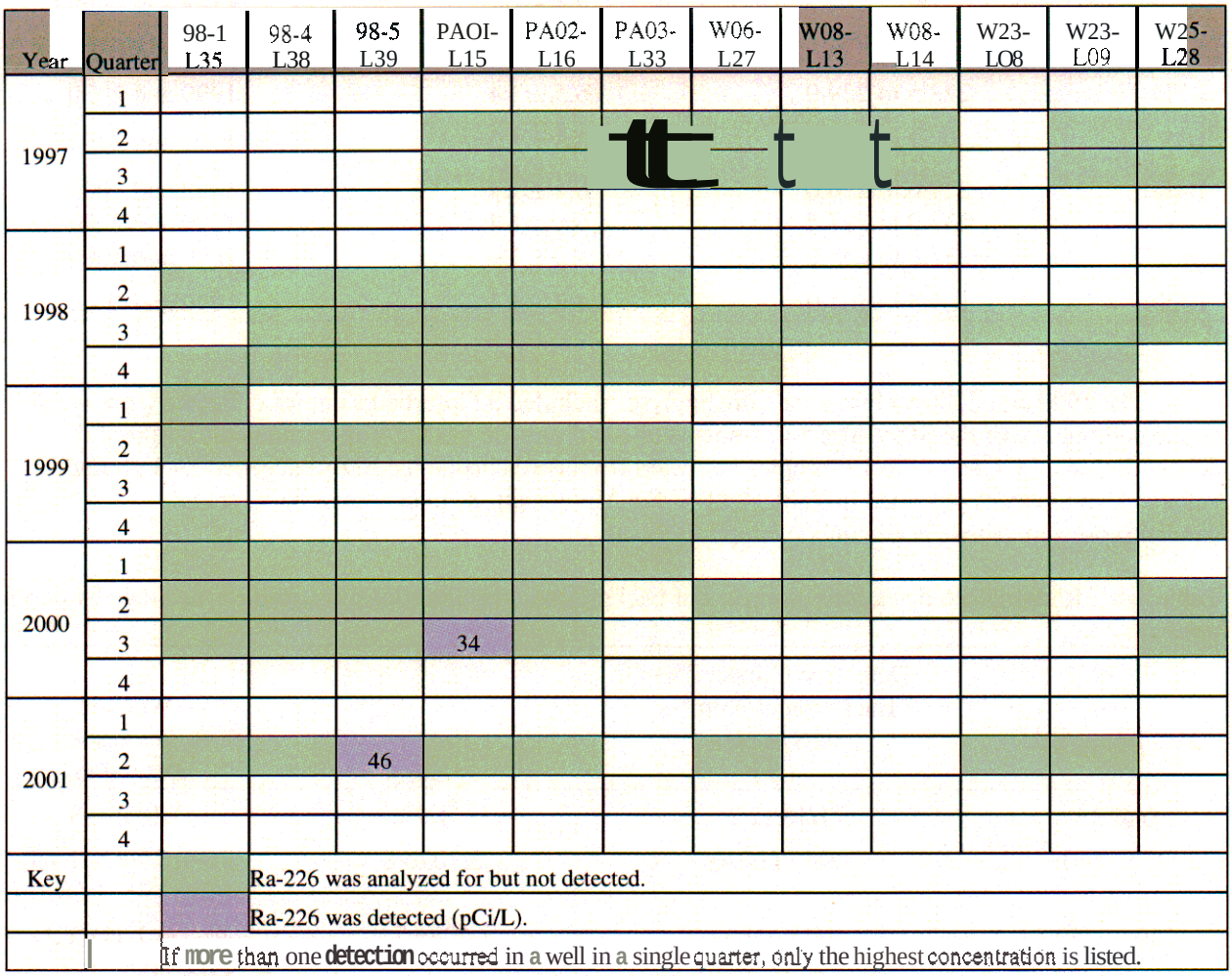

Figure 4-38. Shallow lysimeter monitoring results for radium-226.

4.6.16.3.3 Lysimeter Samples at Depths of 35 to 140 ft—

Thirty-eight samples were collected from 12 lysimeters wells in the 35 to 40-ft depth interval between June 1997 and May 2001 with no positive detections.

4.6.16.3.4 Lysimeter and Perched Water Samples at Depths Greater than 140 ft

A total of 18 water samples and five filtered sediment samples from perched water wells were analyzed for Ra-226 between 1997 and September 2000 with no positive detections. No data are available for the other lysimeter samples obtained at depths greater than 140 ft because the volumes of water collected were insufficient to perform the analysis. The USGS does not analyze samples from perched water Well USGS-92 for Ra-226.

4.6.16.4 Aquifer. A total of 191 samples were analyzed from 15 aquifer wells in the vicinity of the RWMC, with three positive detections of Ra-226 between 1996, when Ra-226 monitoring was initiated, and April 2001 (see Table 4-83). All of the detections exceed the aquifer 1E-05 risk-based concentration of 1.83 pCi/L, and one result of 5.4 ± 1.5 pCi/L exceeds the MCL of 5 pCi/L. The USGS does not analyze for Ra-226 in the eight RWMC wells it manages, controls, and routinely samples. Figure 4-39 shows when samples were taken from each of the 15 wells and when Ra-226 was positively detected. As shown, Ra-226 was not detected in any of the wells in at least two subsequent sampling events following the September 2000 detection.

All sample results for Ra-226 were obtained by direct gamma spectrometric analysis, which provides an adequate screening analysis but is not suitable for drinking water compliance purposes. Because drinking water compliance is required only for the RWMC Production Well, the MCL is used for the other wells as a guideline for comparison.

4.6.16.5 Summary of Radium-226. Vadose zone core samples were collected inside and outside the SDA. Results from cores outside the SDA were near background concentrations. Cores taken from the B-C and C-D interbeds inside the SDA contained Ra-226 above the background concentration of about 1 pCi/g. The samples did not contain elevated U-235, which is known to interfere with Ra-226 results. Therefore, the vadose zone core sample results suggest that Ra-226 is present in the vadose zone above background concentrations.

Table 4-83. Positive detections of radium-226 in aquifer wells.

Aquifer Well	Concentration ± 1σ (pCi/L)	Confirmation Flag[a]	Date
OW-2 (1 mi south of SDA)	4.0 ± 1.3	A	October 2000
M11S (upgradient)	4.8 ± 1.3	A	September 2000
M17S	5.4 ± 1.5	A	September 2000

a. Confirmation flag:
A = No second sample collected, no reanalysis performed.
Note: Concentrations in red bold exceed the maximum contaminant level of 5 pCi/L.

Year	Quarter	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	OW-2	A11 A31
1996	1															
	2															
	3															
	4															
1997	1															
	2															
	3															
	4															
1998	1															
	2															
	3															
	4															
1999	1															
	2															
	3															
	4															
2000	1															
	2															
	3							4.8						5.4		
	4														4.0	
2001	1															
	2															
	3															
	4															

Key
Ra-226 was analyzed for, but not detected.
Ra-226 was detected (pCi/L).
If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.

Figure 4-39. Aquifer monitoring detections for radium-226.

Lysimeter and groundwater sample results do not corroborate Ra-226 presence in the vadose zone core. Of more than 150 lysimeter samples, Ra-226 was detected only twice, both times from the 0- to 35-ft interval, with no detections in the deeper lysimeter or perched water wells. Of the 191 groundwater samples, Ra-226 was detected three times. One of the detections was upgradient of the SDA and another was about 1 mile south of the SDA. The third detection was from a well within the SDA boundary. The detection rates for Ra-226 are shown in Table 4-84. The distribution of Ra-226 detections at the various depth intervals is shown in Figure 4-40.

Table 4-84. Detection rates for radium-226 in all media.

Media	Detection Rate (%)	Range of Detected Concentrations	Number of Detections > Risk-Based Concentration[a] or MCL[b]	Wells with Concentrations > Risk-Based Concentration or MCL
Vadose zone (0 to 35 ft)				
Cores	7.7	1.7 pCi/g	0	None
Soil moisture	2	34 to 46 pCi/L	2	PA01, 98-5
Vadose zone (35 to 140 ft)				
Cores	14.6	2.10 to 8 pCi/g	*0*	None
Soil moisture	0	Not applicable	*0*	None
Vadose zone (140 to 250 ft)				
Cores	21.1	2.60 to 7.9 pCi/g	0	None
Soil moisture	0	Not applicable	0	None
Vadose zone (>250 ft)				
Cores	0	Not applicable	*0*	None
Aquifer	1.6	4.0 to 5.4 pCi/L	3	M11S, M17S, ow-2

MCL = maximum contaminant level

a. For **vadose zone cores, the 1E-05 risk-based concentration is 10.87 pCi/g.**

b. For lysimeter, perched water, and aquifer samples, the **MCL is 5 pCi/L.**

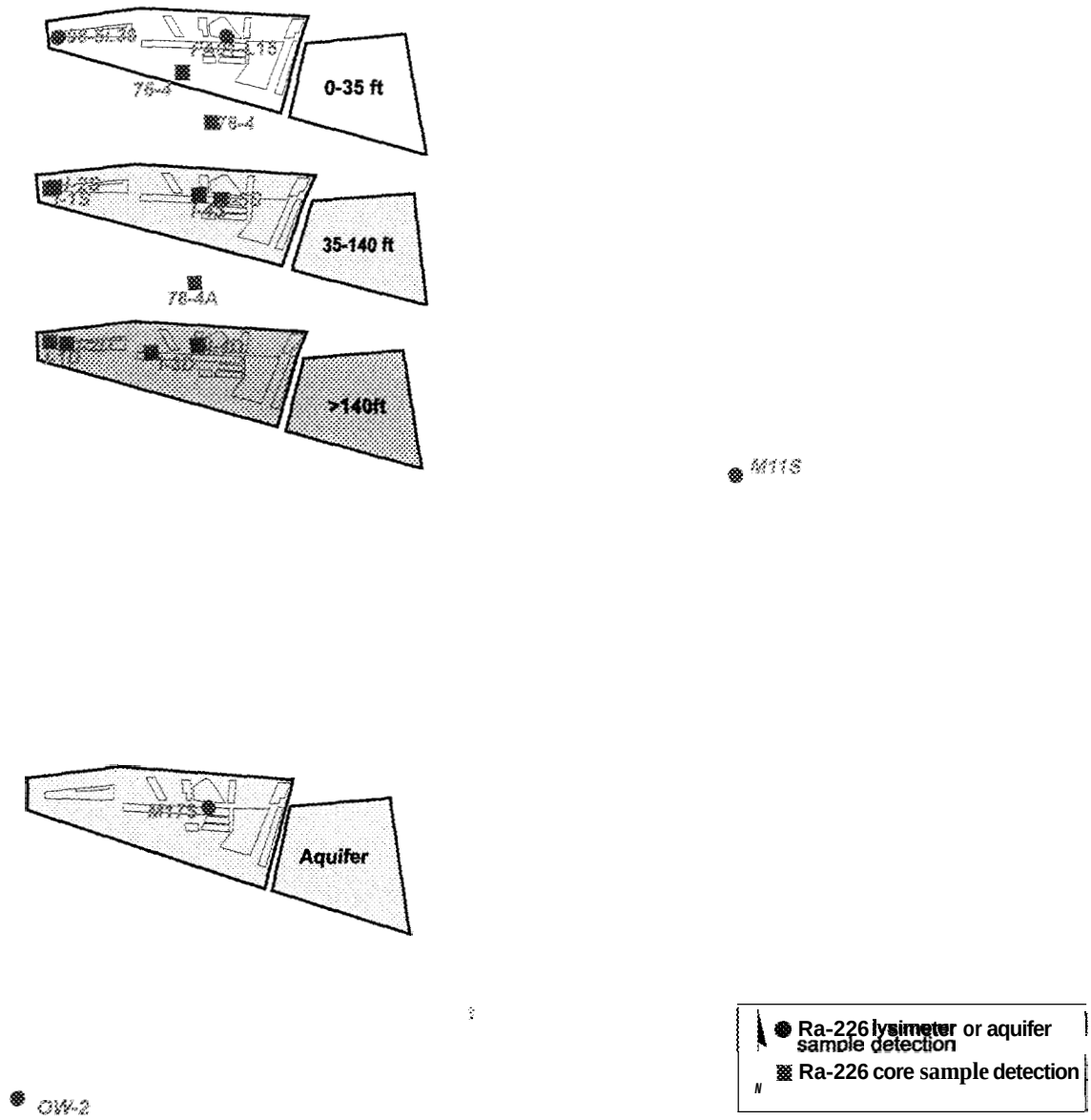

Figure 4-40. Locations of vadose zone core, lysimeter and aquifer samples with detectable concentrations of radium-226, by depth interval.

Whether the Ra-226 measured in the vadose zone core samples is attributable to Ra-226 or to interference from U-235 is uncertain. Therefore, the sample data are "J" flagged, indicating the uncertainty and bias associated with the results, and the influence of the U-235 on the Ra-226 data is indeterminate.

The INEEL is implementing modifications for analyzing Ra-226 to improve confidence in the analytical results. The accuracy of Ra-226 analysis is improved by use of alpha spectrometry or by measuring the equilibrated daughters with gamma spectrometry.

4.6.17 Strontium80

Strontium-90 is a radioisotope that is generated by nuclear reactor operations. Strontium-90 is a fission product that decays by the emission of beta particles with a 28.8-year half-life. It was identified in the IRA as a COPC, primarily from the crop ingestion exposure pathway (Becker et al. 1998). Available information about the presence of Sr-90-bearing waste in the SDA and available Sr-90 monitoring data for all media were reviewed for this report and are summarized below. The sampling data in this section were evaluated against the comparison concentrations in Table 4-85. The presence of Sr-90 below a depth of about 10 ft is not relevant to the crop ingestion pathway; however, the data for all depths were evaluated.

Table 4-85. Comparison concentrations for strontium-90.

Surface Soil Background Concentration[a] (pCi/g)	Risk-Based Soil Concentration[b] (pCi/g)	Aquifer Background Concentration[c]	Maximum Contaminant Level (pCi/L)	Risk-Based Aquifer Concentration[b] (pCi/L)
0.49	55.11	0	8	6.44

a. The value shown is the upper 95% tolerance limit with 95% confidence for cornposited surface soil (Rood, Hams, and White 1996).

b. The calculated risk-based concentration is equivalent to an increased cancer risk of 1E-05.

c. Knobel, Orr, and Cecil (1992).

4.6.17.1 Waste Zone. About 6.44E+05 Ci of Sr-90 was disposed of in the SDA. The waste streams containing the Sr-90 activity are identified in Table 4-86. Spectral gamma logging data provided no information about Sr-90.

Table 4-86. Waste streams containing strontium-90.

Waste Stream Code or Waste Generator	Waste Stream Description	Activity (Ci)	Proportion of Total Activity (%)
INEEL	INEEL reactor operations waste	3.89E+05	60.3
ANL-765-2H	Subassembly hardware	1.39E+05	21.6
ANL-785-1H	Subassembly hardware	6.60E+04	10.1
Miscellaneous	Miscellaneous minor streams	2.19E+04	3.4
ANL-765-1H	Dry active waste	1.48E+04	2.3
CPP-601-1H	Leached vycor glass	9.85E+03	1.5
CPP-601-3H	Dissolved fuel specimens	4.00E+03	1.0
Total Disposals		6.44E+05	100

INEEL = Idaho National Engineering and Environmental Laboratory

4.6.17.2 Surface. In total, 186 soil samples were collected between 1994 and 2000 from in and around the RWMC with 53 positive detections. The positive results ranged from (6.80 ± 0.22) E-02 pCi/g (INEEL 2001) to 1.56 ± 0.12 pCi/g (LMITCO 1997a). All detected **soil** concentrations are less than the 1E-05 surface soil risk-based concentration.

A total of 124 vegetation samples were collected between 1990 and 2000 from the RWMC and control locations yielding 10 positive detections. Detections ranged from (8.61 ± 0.27) E-03 pCi/g (INEEL 2000) to 2.01 ± 0.12 pCi/g (LMITCO 1998).

A total of 210 surface run-off water samples were collected between 1991 and 2000 from the RWMC and control locations yielding four positive detections. The positive results ranged from (4.05 ± 1.17) E-01 pCi/L (LMITCO 1999) to (9.0 ± 1.3) E-01 pCi/L (LMITCO 1996).

4.6.17.3 Vadose Zone. The distributions of Sr-90 in vadose zone core, soil moisture, and perched water in the various depth intervals are discussed below.

4.6.17.3.1 Vadose Zone Core Samples—A total of 352 vadose zone core samples were analyzed for Sr-90 between 1971 and 2000, yielding 24 positive detections. Twelve of the 24 detections were from the 1971 to 1973 timeframe, when there were known cross-contamination problems in the core sampling method (see Section 4.5.5). Table 4-87 shows positive detections of Sr-90 from vadose zone core samples. The detection rates for the various depth intervals are shown in Table 4-88.

Table 4-87. Positive detections of strontium-90 from vadose zone core samples.

Borehole Identification	Sample Depth (ft)	Concentration ± 1σ (pCi/g)	Date
76-1	221.0	0.49 ± 0.06	1976
	221.2	0.42 ± 0.05	1976
USGS-87	231.2 to 233.0	0.46 ± 0.05"	1971
USGS-88	521.0 to 522.0	0.40 ± 0.09"	1971
USGS-89	241.6 to 243.2	0.64 ± 0.07"	1971
	540.0 to 545.0	0.30 ± 0.09"	1972
USGS-91	233.8 to 236.3	1.20 ± 0.10"	1972
	243.2 to 245.1	0.50 ± 0.09"	1972
USGS-92	5.0 to 7.5	0.24 ± 0.07"	1972
	88.5 to 90.0	0.30 ± 0.09"	1972
	223.0 to 225.5	0.30 ± 0.09"	1972
USGS-93	13.8 to 14.0	0.40 ± 0.09"	1972
	101.0 to 103.0	0.69 ± 0.11[a]	1972
	103.0 to 105.0	0.40 ± 0.10[a]	1972
D02	1.2 to 1.7	0.19 ± 0.03	1987
	15.5 to 16.0	0.13 ± 0.03	1987
4E	10.0 to 22.5	0.92 ± 0.10	1994
5E	18 to 21	0.75 ± 0.09	1994
	98 to 104	0.25 ± 0.07	1994
3v	100 to 104	0.41 ± 0.08	1994
4v	105 to 118	0.19 ± 0.06	1994
8V	100 to 125	0.53 ± 0.09	1994
10V	7 to 10	0.35 ± 0.05	1994
	98 to 124	0.26 ± 0.06	1994

a. The 1971 and 1972 data are questionable because of cross-contamination concerns (see Section 4.5.5).

Table 4-88. Summary of strontium-90 occurrences in vadose zone core samples.

Depth Interval (ft)	Number of Detections/ Number of Samples (%)	Range (pCi/g)	Wells or Boreholes with Detections
0 to 35	7/46 (15.2)	0.13 to 0.92	4E, 5E, 10V, D02
35 to 140	8/145 (5.5)	0.19 to 0.69	5E, 3V, 4V, 8V, 10V
140 to 250	7/148 (4.7)	0.30 to 1.2	USGS-92, USGS-91
More than 250	2/13 (15.4)	0.30 to 0.40	USGS-89, USGS-88

All of the detections from cores located outside the SDA are questionable because they are from the early 1970s, when coring and sampling techniques may have introduced contamination into the boreholes (see Section 4.5.5; Barraclough et al. 1976; DOE-ID 1983). Results from cores USGS-91, USGS-92, and USGS-93 inside the SDA also are in that questionable data set.

Strontium-90 is present in surface soils from nuclear fallout at concentrations of about 0.4 ± 0.2 pCi/g (Rood, Harris, and White 1996). Most Sr-90 results are approximately the same as background levels, with the exception of USGS-91 at 1.2 pCi/g, which is slightly higher but comes from the 1970s data set. All sample concentrations were less than the 1E-05 risk-based soil concentration of 55.11 pCi/g.

4.6.17.3.2 Lysimeter Well Samples at Depths of 0 to 35 ft—A total of 72 shallow lysimeter well samples were analyzed for Sr-90 between 1997 and May 2001, with seven positive detections (see Table 4-89). Two of the samples were above the MCL for the aquifer.

The positive sample results were not confirmed by reanalysis of the original sample. The occurrence of the positive detections relative to the samples that had nondetectable Sr-90 is shown in Figure 4-41. The 52.1 pCi/L result obtained in Well W06-L27 was not confirmed by reanalysis, and Sr-90 was not detected in that lysimeter in the five sampling events subsequent to that detection.

Table 4-89. Detections of strontium-90 in shallow lysimeter samples.

Lysimeter	Depth (ft)	Concentration ± 1σ (pCi/L)	Confirmation Flag[a]	Date
W23-L08	11.8	3.8 ± 1.1	A	June 2000
PA02-L16	8.7	**9 ± 2**	A	September 2000
W06-L27	11.8	**52 ± 4**	A	August 1997
PA03-L33	10.0	3.8 ± 1.0	A	March 2000
98-1L35 (SDA-01)	16.5	2.2 ± 0.7 3.5 ± 1.0	A	November 1999 March 2000
98-4L-38 (SDA-08)	17.0	3.5 ± 0.9	A	March 2000

Confirmation flag:
A = No second sample collected, no reanalysis performed.
Note: Concentrations in red bold exceed the maximum contaminant level of 8 pCi/L.

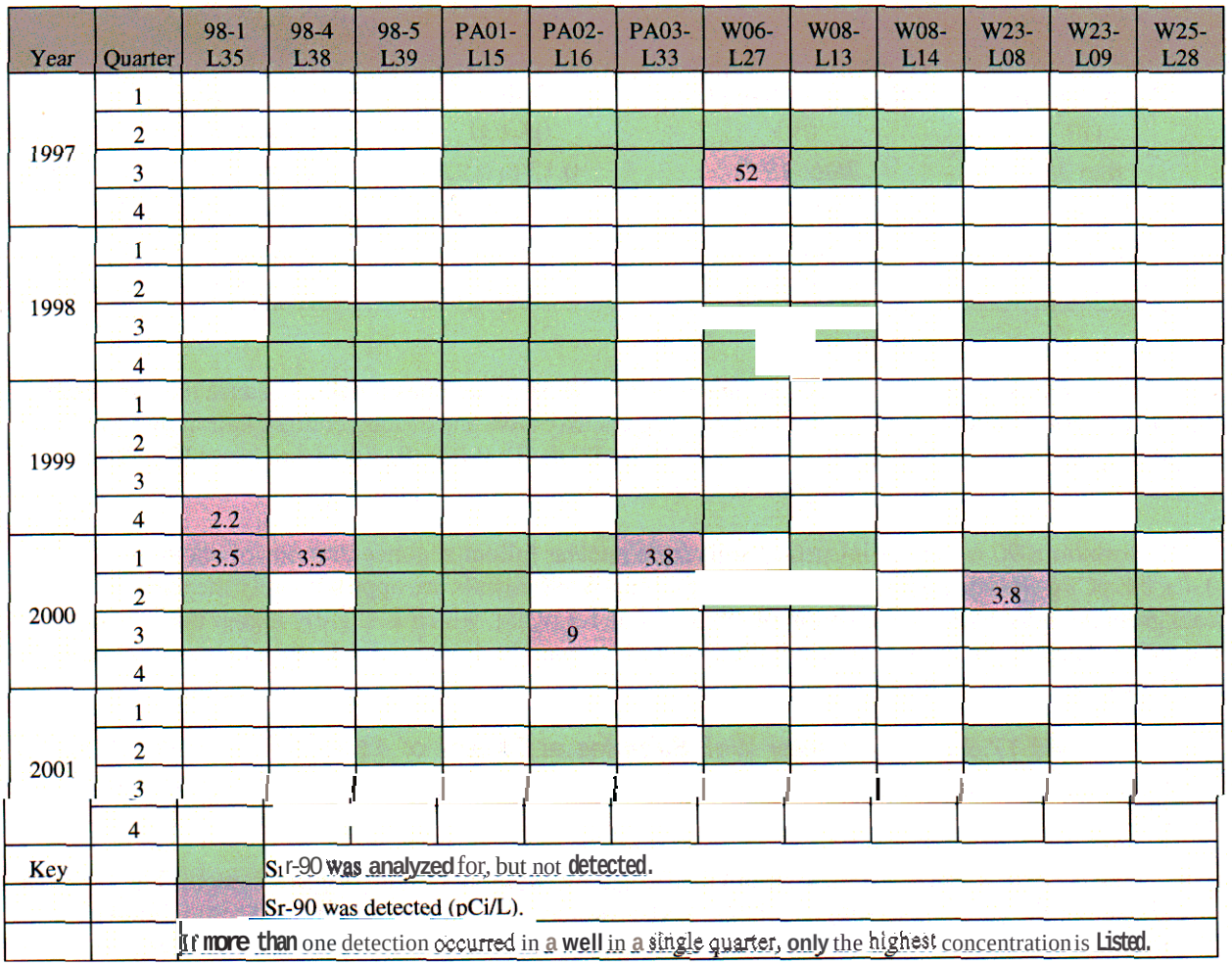

Figure 4-41. Occurrence of strontium-90 in shallow lysimeter samples.

***4.6.17.3.3 Lysimeter Samples at Depths of 35 to 140 ft*—In** total, **14** samples were collected from eight lysimeter wells between 1997 and 2001 with one positive detection. The lysimeter wells that yielded sufficient sample volume for Sr-90 analysis were D06-DL01, D06-DL02, TW1-DL04, and D15-DL06. Five other lysimeters in this depth interval were not analyzed for Sr-90 because the volume of water collected was insufficient. The positive result was 4.1 ± 1.2 pCi/L in lysimeter TW1 DL04 from November 1998. The detection could not be confirmed by reanalysis because of the **limited** sample volume available. The detected lysimeter concentration did not exceed the MCL of **8** pCi/L.

4.6.17.3.4 Perched Water Samples at Depths Greater than 140 ft—A total of 42 perched water well samples and 10 filtered sediment samples were analyzed for Sr-90 by the USGS and **the INEEL** between 1972 and March 2000. The **results** included one positive detection and that detection exceeded the aquifer MCL of 8 pCi/L *(see* **Table** 4-90).

Subsequent water samples collected from lysimeter and perched water Well USGS-92 through March 2000 have not tested positive for Sr-90 detections. The positive water sample result obtained in April 1980 was not confirmed by reanalysis of the original sample. No **data** are available from lysimeters at depths greater than 140 ft because the volume of water collected was insufficient to perform the analysis.

Table 4-90. Positive detections of strontium-90 from lysimeter wells and perched water wells.

Lysimeter or Perched Water Well	Depth (ft)	Concentration ± 1σ (pCi/L) Water	Confirmation Flag[a]	Concentration ± 1σ (pCi/g) Filtered Sediments	Date
USGS-92	214	**9 ± 2**	A	Not analyzed	April 1980

a. Confirmation flag:
A = No second sample collected, no reanalysis performed.
Note: Concentrations in red bold exceed the maximum contaminant level of 8 pCi/L.

4.6.17.4 Aquifer. A total of 283 RWMC aquifer well samples were screened for Sr-90 between 1992 and April 2001 by means of gross beta analysis, with 97 of the samples above the gross beta-screening limit of 5 pCi/L. Those 97 samples were analyzed specifically for Sr-90, and three contained detectable amounts of Sr-90 (Table 4-91).

Table 4-91. Aquifer samples with detectable concentrations of strontium-90.

Aquifer Well	Concentration ± 1σ (pCi/L)	Confirmation Flag[a]	Date
M4D	**0.12 ± 0.02**	D	April 1997
	0.17 ± 0.03	D	April 1997
M6S	2.5 ± 0.6	A	April 1996

a. Confirmation flag:
A = No second sample collected, no reanalysis performed.
D = Detection confirmed by reanalysis.
Note: Highlighted values and confirmation flag "D' indicate that positive detection was confirmed.

Subsequent samples collected from M4D and M6S through April 2001 have not tested positive for Sr-90. The distributions of Sr-90 detections and nondetections in the aquifer between 1992 and 2001 are shown in Figure 4-42 for the USGS and INEEL wells.

Samples from INEEL aquifer Wells M3S and M7S were split with the USGS and compared. None of the samples split with the USGS between 1993 and July 2000 yielded positive detections for Sr-90.

Besides the 15 RWMC monitoring aquifer wells routinely sampled by the INEEL, the USGS manages, controls, and routinely samples eight other wells in the vicinity of the RWMC. A total of 669 USGS aquifer well samples in the vicinity of the RWMC were analyzed for Sr-90 between 1972 and January 2001 with 11 detections. Detectable concentrations measured in the USGS wells are shown in Table 4-92. The USGS detections and nondetections between 1972 and 1991 are shown in Figure 4-43.

Six of the 11 detections associated with the USGS aquifer wells occurred between 1972 and 1974, shortly after the wells were drilled and installed. The 1972 to 1974 results are questionable because of cross-contamination problems (Barraclough, Robertson, and Janzer 1976). Subsequent samples collected from the USGS aquifer wells from 1975 through 1995 yielded five Sr-90 detections. Concentrations in USGS-87 exceeded the aquifer 1E-05 risk-based concentration of 6.44 pCi/L and the EPA primary drinking water MCL for Sr-90 of 8 pCi/L, but no detectable concentrations have been measured in USGS-87 since 1987.

Year	Quarter	USGS-87	USGS-88	USGS-89	USGS-90	RWMC Prod	USGS-117	USGS-119	USGS-120	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	A11A31	OW-2
1992	1																							
	2																							
	3																							
	4																							
1993	1																							
	2																							
	3																							
	4																							
1994	1																							
	2																							
	3																							
	4																							
1995	1																							
	2																							
	3																							
	4								2.5															
1996	1																							
	2												2.5											
	3																							
	4																							
1997	1																							
	2											0.17												
	3																							
	4																							
1998	1																							
	2																							
	3																							
	4																							
1999	1																							
	2																							
	3																							
	4																							
2000	1																							
	2																							
	3																							
	4																							
2001	1																							
	2																							
	3																							
	4																							
Key			Sr-90 was analyzed for, but not detected.																					
			Sr-90 was detected (pCi/L).																					
		If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.																						

Figure 4-42. Occurrence of detectable concentrations of strontium-90 in aquifer samples, 1992 through April 2001.

Year	Quarter	USGS-87	USGS-88	USGS-89	USGS-90	RWMC Prod	USGS-117	USGS-119	USGS-120
1972	1								
	2								
	3								
	4								
1973	1		58						
	2								
	3		28						
	4	7							
1974	1								
	2	8	9		7				
	3	15							
	4								
1975	1								
	2								
	3								
	4								
1976	1								
	2								
	3								
	4								
1977	1								
	2								
	3								
	4								
1978	1								
	2								
	3								
	4								
1979	1								
	2								
	3								
	4								
1980	1								
	2								
	3								
	4								
1981	1								
	2								
	3								
	4								
1982	1								
	2								
	3								
	4								
1983	1								
	2								
	3								
	4								
1984	1								
	2								
	3								
	4								
1985	1								
	2								
	3								
	4								
1986	1								
	2								
	3								
	4								
1987	1								
	2								
	3	23							
	4								
1988	1								
	2								6.4
	3								
	4								
1989	1								
	2								
	3								
	4								
1990	1								
	2								
	3								
	4								
1991	1								
	2								
	3								
	4								

Key		Sr-90 was analyzed for, but not detected.
		Sr-90 was detected (pCi/L).
		If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.

Figure 4-43. Occurrence of detectable concentrations of strontium90 from 1972 through 1991 in the U.S. Geological Survey aquifer samples.

Table 4-92. Detectable concentrations of strontium-90 in U.S. Geological Survey aquifer wells.

Aquifer Well	Concentration ± 1σ (pCi/L)	Date
USGS-87	7 ± 2[a]	October 1973
	8 ± 2[a]	May 1974
	15 ± 2[a]	August 1974
	22 ± 3	July 1987
	23 ± 4	September 1987
	7 ± 2	September 1987
USGS-88	**58 ± 4[a]**	March 1973
	28 ± 3[a]	August 1973
	9 ± 2[a]	May 1974
USGS-90	7 ±2[a]	May 1974
USGS-120	6.4 ± 1.6	June 1988
	2.5 ± 0.8	October 1995

Note: Concentrations in red bold exceed the maximum contaminant level of 8 pCi/L
a The 1972 to 1974 data are questionable because of cross-contamination concerns

4.6.77.5 Summary of Strontium-90, Data from the surface soil, vadose zone cores, and lysimeter, perched water, and aquifer well samples do not indicate the widespread presence of Sr-90 in the environment of the RWMC at levels exceeding background concentrations. Strontium-90 detection rates, shown in Table 4-93, decrease with depth, with 9.7% in the shallow lysimeter wells to 1.0% in the aquifer wells. No trends are apparent. No spatial distribution pattern to the detections in the vadose zone or the aquifer wells is evident, and no detectable concentration of Sr-90 has been found in the aquifer wells since 1997. The locations of vadose zone core, lysimeter, and aquifer samples with detectable concentrations of Sr-90, by depth interval is shown in Figure 4-44.

4.6.18 Technetium-99

Technetium-99 is a radioisotope that is generated by nuclear reactor operations. Technetium-99 is a fission product that decays by the emission of beta particles and low-energy gamma rays with a half-life of 2.13E+05 years. It was identified in the IRA as a COPC, primarily from the groundwater and crop ingestion exposure pathways (Becker et al. 1998). Available information about the presence of Tc-99-bearing waste in the SDA and the available Tc-99 monitoring data for all media were reviewed for this report and are summarized below. The sampling data in this section are evaluated against the comparison concentrations for Tc-99 in Table 4-94.

4.6.18.1 Waste Zone. About 61 Ci of Tc-99 was disposed of in the SDA. The waste streams containing the Tc-99 activity are identified in Table 4-95. Spectral gamma logging data provided no information about Tc-99.

4.6.18.2 Surface. Technetium-99 is not on the target analyte list for the surface samples; therefore, no surface data are available for Tc-99.